

14p  
NASA TECHNICAL TRANSLATION

NASA TT F-15,336

INVESTIGATION OF THE POSSIBILITIES OF USING WIND POWER

C. Kromann and J. Juul

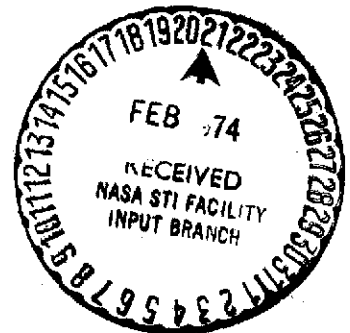
(NASA-TT-F-15336) INVESTIGATION OF THE  
POSSIBILITIES OF USING WIND POWER (Kanner  
(Leo) Associates) 11 p HC \$3.00

N74-15760

CSCL 10B

Unclas  
G3/03 29323

Translation of "Undersogelse af muligheder for vindkraftens  
udnyttelse," Elektroteknikeren, Vol. 45, Dec. 7, 1949, pp. 711-714



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON, D.C. 20546      FEBRUARY 1974

## STANDARD TITLE PAGE

1. Report No. NASA TT F-15,336	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle INVESTIGATION OF THE POSSIBILITIES OF USING WIND POWER		5. Report Date February 1974	
		6. Performing Organization Code	
7. Author(s) C. Kromann and J. Juul		8. Performing Organization Report No.	
		10. Work Unit No.	
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063		11. Contract or Grant No. NASW-2481	
		13. Type of Report and Period Covered Translation	
12. Sponsoring Agency Name and Address National Aeronautics and Space Adminis- tration		14. Sponsoring Agency Code	
15. Supplementary Notes  Translation of "Undersogelse af muligheder for vindkraftens udnyttelse," Elektroteknikeren, Vol. 45, Dec. 7, 1949, pp. 711-714			
16. Abstract  The present translation consists of Kromann's critique of several of Juul's articles in <u>Elektroteknik- eren</u> and of Juul's riposte. For example, <u>Kromann argues</u> that it should not be expected that wind tunnel experi- ments, necessary as these are for finding the best vane design, will yield the same result as real conditions; Juul counters that the same efficiency can be obtained in the open air as in a wind tunnel and that, in any case, this point will be investigated in greater detail in the near future. Kromann has misgivings about building windmills on the west coast of Jylland because he fears that the force of the wind there is too variable; Juul counters that wind-force measurements show that this fear is unfounded (the corresponding curves are given).			
17. Key Words (Selected by Author(s))		18. Distribution Statement  Unclassified	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 9 11	22. Price 300

## INVESTIGATION OF THE POSSIBILITIES OF USING WIND POWER

C. Kromann and J. Juul

By Manager C. Kromann, Aerø, Marstal

/711\*

Further to his earlier articles in Elektroteknikeren, No. 7 (1947) and No. 10 (1948), Sectional Engineer Johs. Juul, Haslev, wrote in No. 20 (1949) a new article entitled "Investigation of the possibilities of using wind power."

The first-mentioned article was countered in No. 14 (1948) by Director A. R. Angelo, who pointed out both that the production price for a windmill must be estimated at least at 12 øre per kWh and that the capital invested in windmills with a yearly production of 50 million kWh would be just as great as for a steam power plant with a yearly production of 360 million kWh, whereupon he deplored that such was the case but asserted that it was better to gain a clear understanding of the matter than constantly to talk and write about the significance of wind power for the future's electricity supply.

To these objections Engineer Juul countered in No. 16 (1948) that he was still optimistic, and that his optimism had been strengthened by the results of experiments, which have since been embodied in the said new article of No. 20.

With regard to the foregoing, I should first of all like to comment that all of Denmark's inhabitants must be regarded as concerned with this question, if only for the simple reason that they fear premature depletion of Denmark's fuel reserves -- into which far too great inroads have already been made -- should the existing unstable state of affairs long endure, while on the other

---

\* Numbers in the margin indicate pagination in the foreign text.

hand, they desire the use of electricity to be extended, and therefore think first and foremost of wind power as the ideal adjunct; but the man in the street is in no position to arrive at a thorough judgment of the situation by himself and is obliged to turn to the experimental results and their interpretation that are made public, and inasmuch as Engineer Juul's article contains pronouncements and estimates which, in my opinion, need to be elucidated in detail, I should like to state the following:

With regard to "Wind tunnel experiments" it may be noted that necessary as these experiments are for finding the best vane design, it should not be expected that wind tunnel experiments with a pretty constant air current will yield the same results as real conditions.

Perhaps experimental results have hitherto been overestimated, and in any case it is characteristic that no responsible manager /712 of an electrical powerhouse has to my knowledge suggested further extensions with windmills.

On page 623, to be sure, Engineer Juul states that the statistics for the production of direct-current windmills is no measure of what can be produced by an alternating-current system. Perhaps not; but it can surely give an inkling of the discrepancy between calculated and real production, and under No. 31 of the 1947-1948 statistics for Danish provincial electrical powerhouses it is entered that with a 2 x 70 kW windmill 155,000 kWh are produced, and under No. 60 it is entered that with a 60 kW windmill, 44,000 kWh are produced. As far as I know, both windmills are of the propeller type, and in any case the results are pretty far from the figures employed in their time on the basis of measurements of wind-force conditions.

Perhaps Engineer Juul's optimism is due to the plan mentioned on page 627 for windmills placed at intervals of about 100 m on a western beach and interconnected by means of 50 kV mains.

Again I am inclined to skepticism, especially as regards Jylland, and that goes for both emplacement and mains. Everybody who has any familiarity with the behavior of the sea knows that waves come in considerable lengths and can break almost simultaneously over very long stretches of coast, and inasmuch as the roughness of the sea depends on the wind, it seems probable that several windmills placed at intervals of about 100 m along the coast will simultaneously undergo gusts of wind and therefore be simultaneously subject to greater output and voltage alterations, which is no doubt not exactly the aim we ought to have in view.

The plan to build 50 kV connecting lines relatively close to a stretch of coast I must regard as rash, partly because they are conceived to be built in the teeth of westerly winds, partly because they are conceived to be built for 50 kV, which in damp air saturated with salt water will probably give rise to insulation problems.

Inasmuch, then, as Engineer Juul is still working on plans for the large-scale operation of windmills, presumably he will not take it amiss if others advance divergent viewpoints, since what we are talking about is not persons, but things, and so I am taking the liberty of advancing the following viewpoints for consideration.

As far as stronger wind forces are concerned, the wind generally comes in gusts or surges with varying maximum values and with varying intervals between gusts, for which reason I propose that this relationship be investigated, inasmuch as no such investigation seems to have been undertaken.

Insofar as such investigations will yield a usable result, I propose that windmills be built at appropriate distances inland from the coast, by which means I believe a more uniformly

distributed production can be achieved, because the gusts will then reach the windmills at staggered intervals. The inland connecting lines to the east will undergo the least possible action of westerly winds and need not be built for 50 kV, but for a lower, more reasonable voltage, and at the end of the row of windmills the connecting line will be connected through a transformer to a better protected 50 kV main.

Further: On page 635 we read the following: "Owing to the occurrence of periods of calm, wind power plants will require full reserves of another power. Thus there are only KWh in wind power, but no kW."

"It will, however, be indirectly possible to save money that would be spent on the construction of thermal power plants, because wherever sufficient wind power plants are to be found, there will be a need for thermal power plants on the average only about 40% of the time."

Is not such an assertion in need of further clarification? In any case, it is not self-evident why an assertion that windmills will require full reserves of another power, should be followed by an assertion that it will be indirectly possible to save money that would be spent on the construction of thermal power plants. It would seem that initial expenditures and operating economy have contracted a not quite legitimate relationship.

According to the introduction, opinions are sharply opposed as to whether investigations dealing with large-scale utilization of wind power for electricity generation should be continued or discontinued, but inasmuch as this question is still being mulled over, and even with so much optimism (page 632) that plans are afoot for systems consisting of groups of 30 double standard windmills at a total cost of 4,200,000 Kr., it might be most proper for these investigations to be carried out on a purely

private or a public initiative, for I believe that finding a manager who, on the basis of available information and with /713  
Director Angelo's pronouncements in mind, would dare recommend to his company the purchase of windmills in groups, will give rise to inordinately great difficulties.

If Engineer Juul can hold on to his optimism concerning the large-scale utilization of wind power, I will take the liberty of suggesting, on the basis of the statements on page 631 to the effect that works of this kind ought to be carried out in periods of unemployment because 80% of the construction costs for windmills come from wages, that the State's cooperation be sought in the guise of an appointed board or commission -- after all, so many boards and commissions are being appointed -- for the purpose of definitely establishing once and for all whether anything of value to the nation is concealed behind the plan.

Yet I deem it necessary to add that if the recommendation of an appointed board or commission with regard to this subject is to be of any value to powerhouses, a technically trained member nominated by the Electricity Board must be found, as well as a member nominated by the Danish Powerhouse Union and a member appointed from among powerhouse managers, which latter member must be intimately acquainted with the operation of a large wind power plant.

---

By Sectional Engineer J. Juul, Haslev.

The above article by Manager C. Kromann, Marstal, Aerø, calls for the following remarks:

With regard to the certainty that the same efficiency can be obtained in the open air as in a wind tunnel, I shall refer the reader to the remarks at the bottom of page 620 of my article.

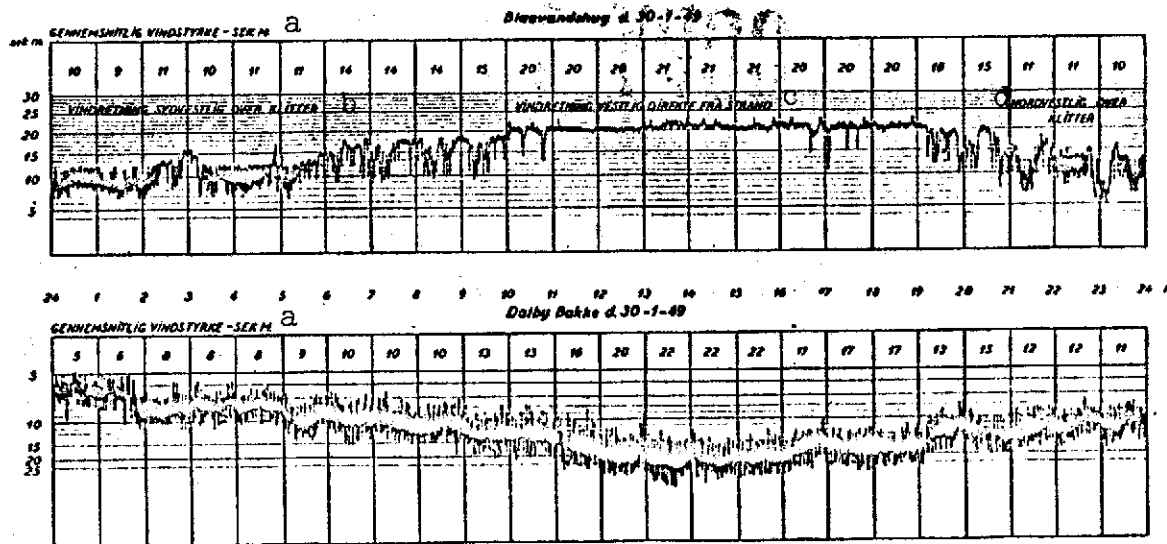
This point will be investigated in greater detail in the near future, when an experimental windmill executed according to the standard system will be set up in South Sjaelland.

This experimental model is being built one-third the size of the windmill mentioned in my article, i.e., with a wheel diameter of 8 m and a sail area of 50 mm<sup>2</sup>. The purpose of building this windmill is precisely to elucidate the point in question and to work out the necessary automatics. This experimental model, moreover, is being built in such a manner that the axial effect of the wind on it can be measured and recorded, whereby it should be possible to arrive at exact data for designing a standard windmill.

Manager Kromann has misgivings about building windmills on the west coast of Jylland because he fears that the force of the wind there is too variable. Wind-force measurements show that this fear is unfounded. The curves below were recorded with two anemometers set up at an altitude of 13 m about 100 m north of Blaavandshug lighthouse and on Dalby Bakke near Haslev. Conditions at Blaavand were such that with a wind blowing due west there was a free passage of about 300 m for the wind from the coastline to the anemometer. With a southwesterly and northwesterly wind direction the wind had to pass over relatively high sand dunes, which occasioned gusts that depend on purely local conditions. This can be most clearly seen, for example, from the wind measurements recorded in the windy weather which Denmark had on the 30th of January of this year, and which was caused by an eastward-moving depression that began by generating a wind from the southwest, which veered to the west and from there to the northwest. It can be clearly seen how the southwesterly and northwesterly winds come in like a gust arising out of the whirlwinds produced by the sand dunes whereas the wind from about 11 to 19:00 comes in from the North Sea like an almost constant air current. Such a constant wind can no longer be found inland, as can be seen from the measurements at Dalby Bakke, which always show a



fluctuating wind force that depends on the local configuration of the ground. It can therefore be assumed that a very large number of windmills built at some distance will together produce an effect whose curve will fall and rise uniformly in about the same manner as the load curve of a large electric powerhouse.



Key: a. Average wind force: sec/m  
 b. Wind direction: southwesterly over sand dunes  
 c. Wind direction: westerly direct from beach  
 d. Wind direction: northwesterly over sand dunes

Investigations have therefore shown that a level western beach like, for example, on the west coast of North Schlesweg experiences both the most powerful and the most uniform wind.

As regards inconveniences due to the salinity of the damp North Sea air, suffice it to say that this only happens in a western storm. Such a storm conveys the salt-saturated air inland at 80-100 km/hour and is therefore, practically speaking, about of like nature throughout the country. By using modern unbreakable insulators I think this phenomenon need not give rise

to any particular difficulties inasmuch as experience has shown /714  
that it is only in the event of cracked insulators that fluctuations in operation take place which are due to saline air.

As regards what I stated about an indirect kW saving on page 635 of my article, I will admit that a lot more could be said about this question.

Where wind power plants are to be found in sufficient numbers, it will be possible to relieve heat power plants of 60-70% of their production. It is immediately apparent that they will therefore also be exposed to less wear and tear than where they bear the full brunt of production, and there will be more time for maintenance and reparation of the plants.

Under these conditions it should be possible to reckon with a longer service life for the heat power plants, and as a result it should also be possible to cut back on expenditures for kW.

I agree with Manager Kromann that the question of the large-scale utilization of wind power for electricity generation for public works is a social question, and that it must be treated and developed from such a point of view, which is what I thought I expressed in my article in Elektrotekniker. But then, Professor P. La Cour's work on the utilization of wind power, too, was undertaken from this point of view. That his work was ahead of its time and acquired significance in another direction is another matter. I believe that the time has now come for the matter to be taken up again, and should my investigations constitute a modest contribution thereto, my purpose will have been achieved.

In England the ERA [expansion unknown] recently investigated the application of wind power. These investigations have led to

the building at present of an experimental windmill of about the same dimensions as those of the standard windmill sketched in my article. In the account of the English investigations it is stated that the question as far as England is concerned is more of an economic than a purely technological nature, which is natural for a coal-producing country like England. In Denmark, which possesses no other natural sources of power than wind power, it seems to me that the question is more urgent and far-reaching than in England.

Hopefully, after Sea's experimental windmill has been running in the course of the coming year, a practical demonstration will be given of the correctness of the calculations adduced in my article, and then there will certainly be every reason to pursue the matter on a broader basis.